Section 3 -- The Salinity Tolerance of *Vallisneria americana*

The physiological tolerance of the VEC to salinity is used to identify a particular salinity or range of salinities that will maintain the VEC in the estuary. Using a relationship between freshwater inflow and salinity in the estuary, a minimum flow can be identified that will protect the VEC from significant harm. Salinity tolerance was determined based on analyses of data from monitoring of field populations and from laboratory mesocosm experiments designed to measure the effects of salinity on growth and mortality. Description of laboratory and field methods may be found in **Appendix D.**

In brief, the laboratory data on salinity tolerance summarized in this report were collected during four experiments conducted between 1996 and 2001 (**Table D-1**, **Appendix D**). Plants were exposed to constant salinity treatments (n = two mesocosms per treatment) for periods of 3 to 10 weeks. Field observations were obtained from an ongoing program, started in 1998, to monitor *V. americana* on a monthly basis in the upper Caloosahatchee Estuary (**Figure 3-1**, Station 1-4).

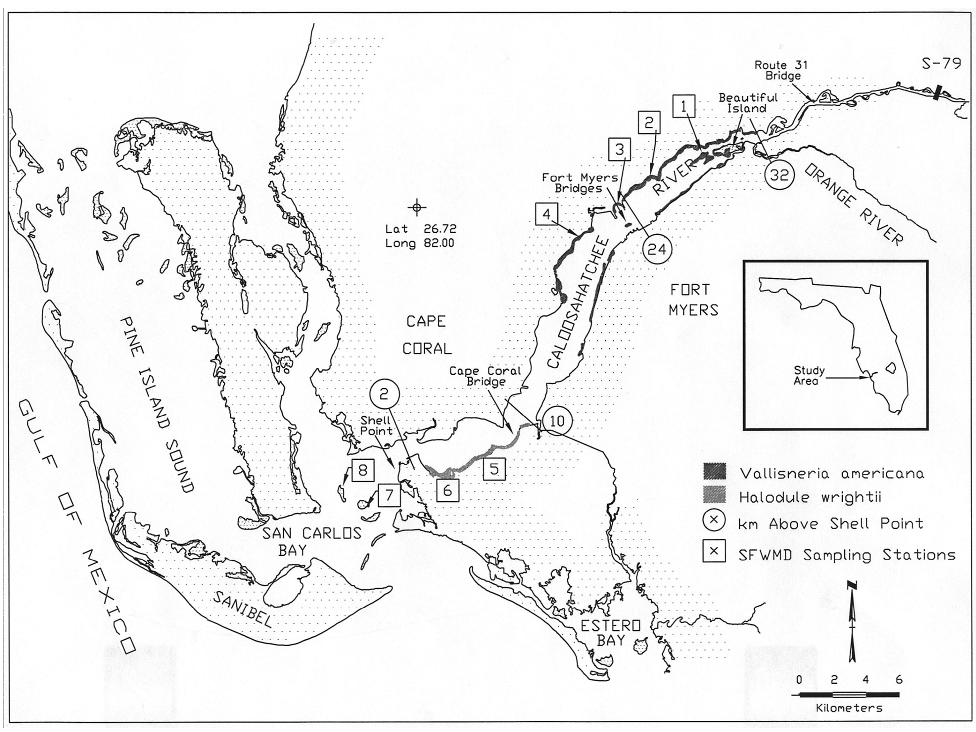


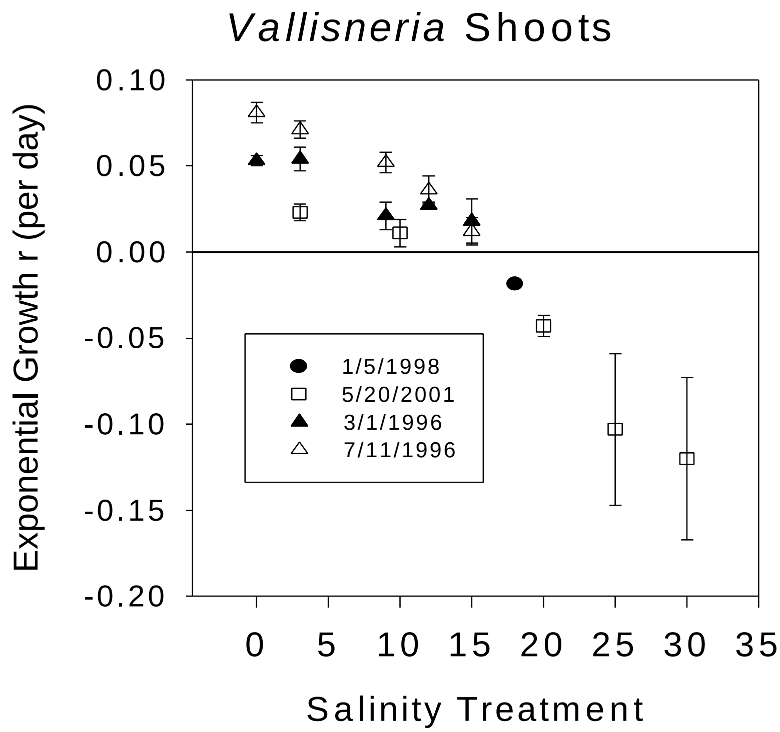
Figure 3-1 Distribution of *Vallisneria americana* and *Halodule wrightii* in the Caloosahatchee Estuary. Also shown are the locations of grass bed monitoring stations and the general locations of salinity recorders at S-79, Rt. 31 Bridge, Fort Myers Bridges, and Shell Point.

Both field and laboratory data were used to select salinity thresholds that could be used to calculate minimum and maximum flow conditions that are needed to maintain the VEC. Field salinity tolerances were identified from plots of plant density as a function of salinity on the day of sampling. Threshold salinities, which reflect the tolerance of *V americana* to salinity stress, were those associated with marked changes in plant density. Laboratory data were examined to identify salinity levels where growth was low, and close to zero. Using non-linearities to identify thresholds is common in methods used to determine flow requirements for streams and rivers (Estevez 2000b).

For *V. americana*, the net growth rates of shoots and blades in the laboratory decreased as salinity increased, with mortality occurring at salinities greater than 15 ppt (**Figure 3-2**). At 18 ppt a 50% loss of shoots would occur in 38 days. At 20 ppt a 50% loss would occur in 16 days. In the region between 10 ppt and 15 ppt, the change in growth in response to a change in salinity was very small. This lack of response was especially evident for the number of blades: growth rates at 10 ppt and 15 ppt were virtually identical. In this zone, plants survived but net growth rates of shoots and blades were very low.

Data from field monitoring agreed with results from the laboratory (**Figure 3-3**, upper panel). Higher densities in the field (> 400 shoots m^{-2}) occurred at salinities less than about 10 ppt. Lower densities (< 400 shoots m^{-2}) were more frequent at salinities above 10 ppt. Ten (10) ppt appears as a threshold because high densities of *V. americana* do not occur at higher salinities. At favorable salinities below 10 ppt where density may be high or low, other factors such as light and temperature may control plant density.

Our laboratory results suggest that for *V. americana* from the Caloosahatchee, growth is low or nil in the 10 ppt to 15 ppt range with mortality occurring at salinities greater than 15 ppt. This agrees well with transplant experiments conducted in the Caloosahatchee that indicated mortality at salinities greater than 15 ppt (Kraemer et al. 1999). Adair et al. (1994) found that the distribution of *V. americana* in Trinity Bay, Texas was limited to salinities less than 10 ppt. In outdoor mesocosm experiments, French (2001) observed minimal growth of *Vallisneria* from the Chesapeake Bay at 10 ppt and 15 ppt. French further concluded that "improving water clarity in Chesapeake Bay may increase distribution, but only into regions less than 10 psu [psu ~ ppt]" (French 2001).



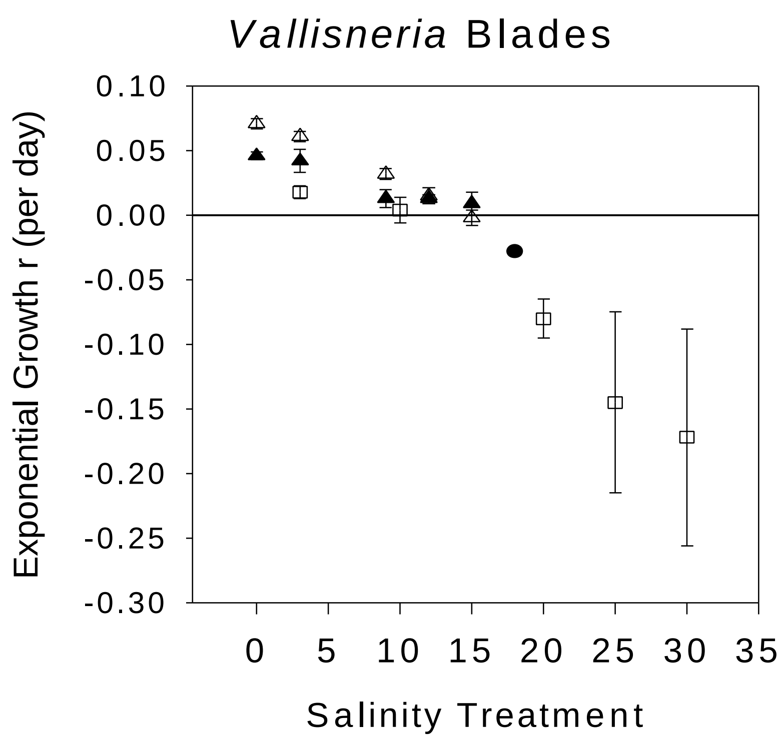


Figure 3-2 Net exponential growth rates (r $\pm$ 95% C.I.) of *Vallisneria americana* measured in laboratory mesocosms during constant exposure to different salinities. A negative value of r indicates mortality.

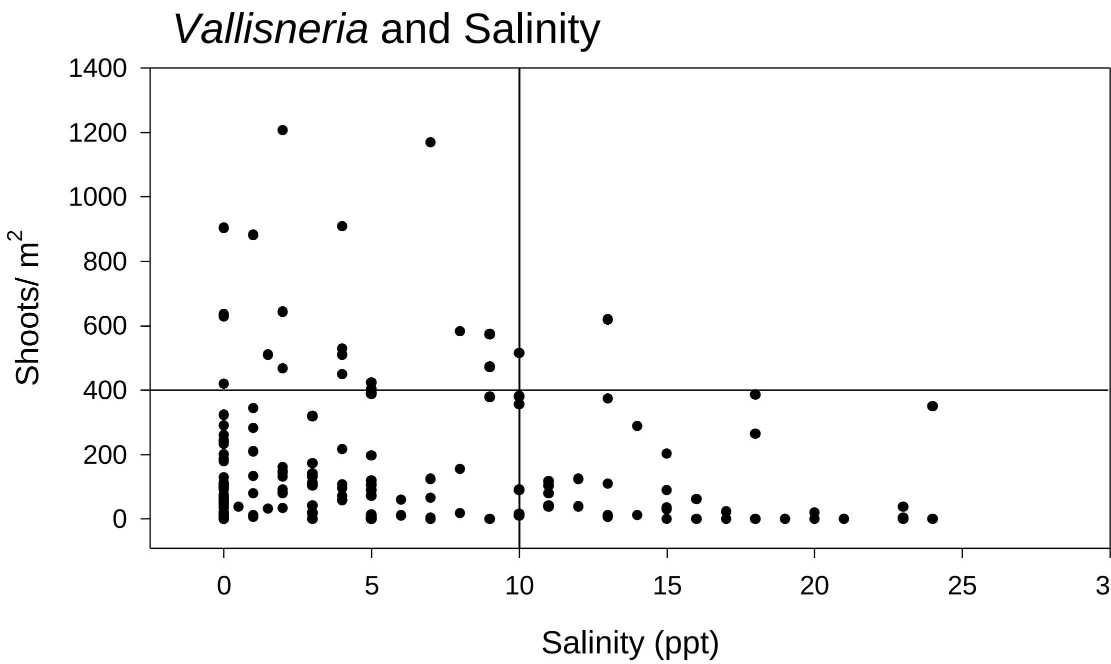


Figure 3-3. Shoot density of *Vallisneria americana* at monitoring stations 1, 2, 3 and 4 as a function of salinity on the day of collection. Data were collected from January 1998 to August 2000.

The combination of results from field monitoring and laboratory experiments conducted by the SFWMD and other investigators agree that 10 ppt is a critical threshold salinity for growth. Salinities above 15 ppt cause mortality. The 30-day averaging period in the MFL rule is consistent with laboratory experiments, which show that *V. americana* can survive exposure to 10 ppt for periods exceeding a month (Doering et al. 1999; French 2001).

The daily average salinity limit of 20 ppt was included in the rule to avoid acute exposure to high salinity. Experiments completed in 2001, suggested that mortality began after 3 days exposure to 20 ppt (**Appendix D, Figure D-4**). Therefore, a one day exposure to 20 ppt appears to be a reasonable limit for acute exposure.

Significant Harm Criteria

The general narrative definition of significant harm proposed by the District for the water resources of an area is as follows: "Significant Harm – means the temporary loss of water resource functions which result from a change in surface or ground water hydrology, that takes more than two years to recover but which is considered less severe than serious harm." (Chapter 40E-8.021 (24), F.A.C.).

In the original technical documentation of the Caloosahatchee MFL, the habitat value of *Vallisneria* beds was identified as the water resource function of interest. Loss of the habitat function of *Vallisneria* beds was defined as occurring when densities fell below 20 shoots/m^2. This was based on best professional judgement and found to be inadequate by the peer review committee (Edwards et al. 2000). On-going investigation of the utilization of *V. americana* beds by estuarine fauna should provide a scientific basis for identifying a threshold density.

Significant harm was originally defined as occurring when loss of habitat function occurred for three consecutive years. The peer review committee concluded that this definition was not supported scientifically. The MFL Rule considers a violation to have occurred if the salinity criteria are exceeded in two consecutive years. Whether this frequency of violation protects against significant harm, defined as loss of habitat function that takes more than two years to recover, is not known with certainty.

Monitoring data provide some limited insight and indicate that violation of the MFL 30-day average salinity criteria can cause the loss of habitat function. **Figure 3-4** depicts the association between 30-day average salinities above 10 ppt and declining densities of *Vallisneria*. The data show that exceedance of the 10 ppt criterion in two consecutive years (1999, 2000) *can* (but may not always) be associated with a reduction in plant density to very low, non-detectable levels. The exact density of plants at which the habitat function is lost remains debatable. However, the absence of plants implies a loss of habitat function. Thus, exceedance of the 30-day average MFL salinity criterion can cause the loss of habitat function.

The period of record for the monitoring data is far too short to answer questions related to recovery with any confidence. If anything, the data depict the cumulative effects of multiple exceedances of the 30-day average MFL salinity criterion. A more sophisticated understanding of *Vallisneria*'s life cycle is required in order to address questions related to recovery.

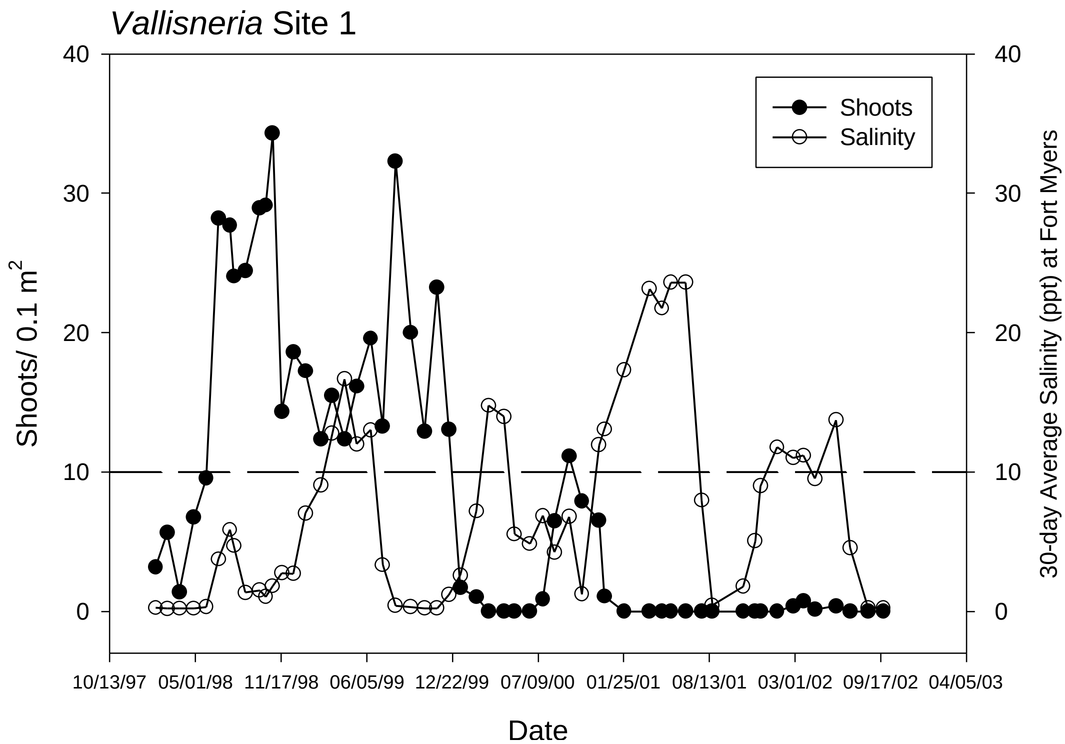


Figure 3-4. Number of shoots at monitoring Station 1 in the upper Caloosahatchee Estuary from January 1998 – September 2002. Also shown is the 30-day average salinity at Ft. Myers.